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Article

Quality of surface waters of the San Pablo-Los Ríos river, for irrigation of agricultural crops

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Abstract: River pollution can be due to the influence of foreign materials, garbage, biological or inorganic waste, among others, influencing the suitability of natural sources that can be used for agriculture, as is the case of the San Pablo River. This research was focused on evaluating the surface waters of the San Pablo River for irrigation of agricultural crops. The TULSMA Book VI, Annex 1, in addition to the ICA-NSF calculation, was used as a reference. Initially, samples were taken at four points along the San Pablo and Santa Rosa Rivers, where activities that have a greater or lesser impact on their pollution have been identified, which may influence their quality. The results of the physicochemical and microbiological analysis of the samples indicate compliance with environmental regulations. The ICA-NSF quality index showed values for the river water with medium quality. This study will allow proposals to be made so that producers and residents of the area can efficiently manage this resource, improve agricultural yields, and conserve the water source and soil.

Keywords: Water conservation, ICA-NSF, river water, index, physicochemical parameters

Resumen: La contaminación de los ríos puede deberse a la influencia de materiales extraños, basura, desechos biológicos o inorgánicos, entre otros, influyendo en la aptitud de las fuentes naturales que pueden ser utilizadas para la agricultura, como es el caso del río San Pablo. Esta investigación se enfocó a evaluar las aguas superficiales del río San Pablo para el riego de cultivos agrícolas. Se utilizó como referencia el Libro VI, Anexo 1 del TULSMA, además del cálculo del ICA-NSF. Inicialmente se tomaron muestras en cuatro puntos a lo largo de los ríos San Pablo y Santa Rosa, donde se han identificado actividades que tienen mayor o menor impacto en su contaminación, las cuales pueden influir en su calidad. Los resultados de los análisis fisicoquímicos y microbiológicos de las muestras indican el cumplimiento de la normativa ambiental. El índice de calidad ICA-NSF mostró valores para el agua del río con calidad media. Este estudio permitirá hacer propuestas para que los productores y pobladores de la zona manejen eficientemente este recurso, mejoren los rendimientos agrícolas y conserven la fuente de agua y el suelo.

Palabras claves: Conservación del agua, ICA-NSF, agua de río, índice, parámetros fisicoquímicos

1. Introduction

The quality of water bodies such as rivers is deteriorating due to anthropic activities such as: effluents generated in populated centers, industrial areas, primary sector activities, and runoff (Jervez et al., 2022). Ecuador has an extensive hydrographic network, originating mainly in the Andes Mountains with mouths in the Amazon River and Pacific Ocean (Simbaña-Farinango et al. 2019). The territory of Ecuador is divided into 31 hydrographic systems, made up of 79 watersheds. These systems correspond to the two watersheds, 24 drain towards the Pacific Ocean and represent 48.07% of the surface of the national territory; and 7 drain towards the Eastern Region, which represents 51.41% of the territory (Cisneros and Pacheco, 2010). The characterization of a river's water quality consists of determining the extent, degree or intensity of contamination, which may be of physical, chemical or biological origin, and the capacity of the system to naturally reestablish the characteristics or conditions it had before the presence of the contaminant (Cajas et al., 2023).

The available volumes of freshwater for agricultural and urban-industrial use worldwide have decreased considerably due to the excessive use of surface and groundwater for agricultural irrigation for food production of a constantly growing population (Quinteros Carabalí et al, 2019). Contamination of the river is mainly due to the introduction of materials foreign to its nature such as: garbage, biological waste, fuels, wastewater, which have caused the loss of biotic and abiotic resources, causing an ecological deficit and mismatch in the food chain (Prado-Vélez et al, 2023). The Babahoyo River suffers from progressive contamination due to various factors such as foreign chemicals, microorganisms, waste from rice mills, sewage and others. Fundamentally, the water is contaminated by human activity because the population is growing every year, and rice mills are another important source of contamination because they daily deposit thousands of contaminating wastes (garbage, chaff, plastics, etc.) (Moreira and Ramos, 2021). Evaluating the quality of water in family farming agroecosystems - which differ in their production proposals - makes it possible to explore the effects of the forms of appropriation of ecosystems and therefore the threats to the biocapacity and sustainability of the systems, as well as the possibilities of proposals generated from local ways of doing agriculture (traditional), and from modes that have at their base the use of inputs from the environment based on ecological principles (organic), as opposed to the proposal of conventional or modern agriculture (Guilcamaigua and Chancusig, 2019).

The territory of the sub-basin has been extensively intervened. Only 4.04% of the territory (28,200 hectares) is protected as part of the Illinizas Ecological Reserve (with a total area of 26,100 hectares, of which 23,700 are within the watershed) and three protected forests (Matiaví-Salinas, Naranjapata and Cerro Guineales-Samama-Mumbes) (M AATE, 2009). Almost half of the total area is suitable for irrigation, but the most remarkable thing is that, in the vast majority of them, irrigation can be carried out without restrictions (CEDEGE and UNDP, 1983). In the San Pablo river basin, in the province of Los Ríos, very few studies have been carried out to determine the quality of the river water; it is important to determine the suitability of the river water, which is used to irrigate crops in the area.

The quality of irrigation water is conditioned by the salts (quantity and type) and sediments that constitute it. It is of utmost importance to know its characteristics, since it influences edaphic properties, increasing its salinity and, consequently, affecting crop yields. In this sense, salt tolerance is an agronomically important trait that is receiving increasing attention among different research groups in the world (Masseroni et al, 2018). In Ecuador, it is observed that in the last decades, the use of water for agriculture intensified and products destined for agroexport were massified, in the eagerness to increase the profits of large capitals (Guilcamaigua and Chancusig, 2019). Water quality indices are tools that allow decision-making to reduce the deterioration of water quality by directly assessing variations in its quality parameters (Pérez et al, 2018). The ICA-NSF methodology is used to determine the quality of river water for human consumption, using weighted weights in its parameters, which has allowed it to be popularized in many countries (Robledo-Hernández, 2022).

The objective is to evaluate the water quality of the San Pablo river by applying the TULSMA and considering the ICA water quality index, to determine physical, chemical and biological parameters for the characterization of water for irrigation of agricultural crops. In addition to analyzing the suitability of the water in terms of its physical, chemical and biological properties, to be used for crop irrigation; taking as a reference for sampling several points along the San Pablo and Santa Rosa rivers, where it has been possible to identify activities that may influence the quality of the river as there are discharges that may affect to a greater or lesser degree to its contamination.

2. Materials and Methods

Each sampling point was identified with a code and geographic coordinates using a Global Positioning System (GPS). The research work was carried out during the month of November 2021, with the specialized service of an accredited laboratory for sampling and physical, chemical and microbiological analysis.

Study area

This research was carried out in the area of Babahoyo - San Pablo River. A descriptive exploratory study was developed in the water body, starting with the collection of samples at points that offered ease of access, safety, representativeness and a permanent flow of water.

The field work began with sampling in the bodies of water, at the determined study points (point 1: Water of the river near the Amelia farm, before joining the crystal river; point 2: Santa Rosa River - near the "El Beldaco" farm; point 3: San Pablo River near the Technical University of Babahoyo; point 4: San Pablo River - 4 de mayo sector). This, in order to obtain current information on water quality in the study area.

Sample analysis: The samples were analyzed once they arrived at the laboratory to guarantee the results of the analyses, considering the sample preservation controls at the time of being transferred to the laboratory once taken at the sampling points. For the research carried out, the parameters for the analysis of the samples were chosen taking as a reference the TULSMA - Book VI Annex 2, Table 3, as well as the Water Quality Index (WQI), developed in 1970 by the National Sanitation Foundation (NSF). Parameters of water quality levels for irrigation, among the selected parameters are: hydrogen potential (pH), temperature, dissolved oxygen % saturation (DO), total dissolved solids (TDS), turbidity, biochemical oxygen demand (BOD5), nitrites, nitrates, sulfates, fecal coliforms (Cajaleón, 2020).

Criteria for determining water quality - environmental regulations: The areas and sampling points were chosen based on the research criteria established in the national regulations, water quality criteria for agricultural or irrigation use (section 5.1.3 of TULSMA).

Criteria for determining water quality ICA-NSF: The assessment of water quality can be understood as the evaluation of its chemical, physical, and biological nature in relation to natural quality, human effects, and possible uses. To simplify the interpretation of monitoring data, there are water quality indices (WQI) (Robledo-Hernandez, 2022). The evaluation of water quality should consider representative indicators that guarantee a comprehensive analysis of the water resource, allowing actions to be taken for its management and control through the different water purification processes; one of the most widely used tools are the water quality indexes (ICA) (Méndez-Zambrano et al, 2020). Once the results of the analysis of the water samples were obtained, the Water Quality Index (WQI), developed by the National Sanitation Foundation (NFS) of the United States, was calculated, which considers several parameters such as pH, temperature, dissolved oxygen, biochemical oxygen demand total dissolved solids, turbidity, nitrates, phosphates and fecal coliforms (Méndez-Zambrano et al., 2020).

This information was obtained by means of formulas, for which the data obtained from the analysis of the samples taken at the points previously established for the study are required. Initially, we worked with the curves already established to obtain the Q values, which decreases as the contamination of the water body increases. To determine the Q values, we worked with the graphs established by Brown (1970), which correspond to each parameter analyzed (Granizo & Toa, 2020). The index was calculated by applying the formula proposed by the NSF, which is based on the weighted arithmetic average of 9 variables, through the equation (Caho-Rodríguez and López-Barrera, 2017).

$$ICA - NSF = \sum_{i=l}^{i=n} Q_i * W_i$$

Where:

Qi corresponds to the scale factor of the variable, depends on the magnitude of the variable and is independent of the other variables.

Wi, represents the importance factor or weighting of variable i with respect to the other variables that make up the index (Freire et al, 2020).

The parameters to be analyzed and their NSF Weight (W) values are shown below in Table 1.

Table 1.

Parameters to be analyzed

Parameter	NSF Weight (W)
pH	0.11
Temperature	0.1
Dissolved oxygen	0.17
Biochemical Oxygen Demand BOD5	0.11
Total Dissolved Solids	0.07
Turbidity	0.08
Nitrates	0.1
Phosphates	0.1
Fecal Coliforms	0.16

Source: Granizo and Toa, 2020

According to the result obtained from the application of the formula for the calculation of the ICA-NSF, the results are analyzed with the help of the classification scale of the water quality index ICA-NSF (Table 2), according to Méndez-Zambrano et al. (2020).

Table 2.

ICA classification proposed by Brown

Description	Range
Excellent	91 - 100
Good	71 - 90
Regular	51 - 70
Mala	26 - 50
Very bad	0 - 25

Note: This table shows the ICA quality index proposed by Mendez-Zambrano et al. (2020).

3. Results

3.1 Analysis of physicochemical results

Not all the parameters evaluated at the sampling points are included in the regulations, but they are considered important for the calculation of the ICA-NSF quality index, such as temperature, OD % saturation, TDS, turbidity, BOD5 and nitrates, as shown in the table of analysis results of the river water samples at the four different monitoring points against the Ecuadorian environmental regulations established in the TULSMA, as shown in Table 3 (Cuvi and Ruiz, 2022). The results obtained show that the four sampling points comply with the Ecuadorian environmental regulations; it can be observed that parameters such as pH, nitrites and sulfates comply with the quality criteria. The temperature decreases in a not very significant way from one sampling point to another. M3 has the lowest reading in relation to the other points, with a value of 28.4°C.

Table 3

Table of sample analysis results.

Parameter	Unit	Results				Quality criteria
		M1	M2	M3	M4	
Hydrogen potential, in situ	U of pH	7,59	7,49	7,54	7,16	6 - 9
Temperature, in situ	ºC	30,00	29,40	28,40	28,80	---
In situ dissolved oxygen, % saturation	%	72,50	69,90	72,90	67,10	---
Total dissolved solids (TDS)	mg/l	88,00	76,00	84,00	104,00	---
Turbidity	NTU	9,22	15,80	13,60	26,10	---
Biochemical Oxygen Demand (BOD5)	mg O2/l	5,85	2,76	2,67	3,54	---
Nitrites	mg/l	0,10	0,07	0,08	0,14	0,5
Nitrates	mg/l	0,16	0,23	0,21	0,22	---
Sulfates	mg/l	9,00	9,00	9,00	12,00	250
Fecal coliforms	MPN/100 ml	161,00	110,00	41,00	200,00	1000

Note: This table shows the average of the results obtained from the physicochemical analysis, for the four sampling points, compared to the environmental regulations in force, admissible quality criteria for water intended for agricultural use, which are presented in Table 3 of Annex 2 of Book VI of the TULSMA (Prepared by the company).

The results of the field measurements indicate that the variability of pH between the four sampling points is negligible, since the values range from 7.16 to 7.59, with the greatest variability being at point M4, and between points M1 M2 and M3 the bias is smaller; these are neutral pH values with a slight tendency towards alkalinity (Table 4). Regarding nitrites, among the 4 sampling points, M2 and M3 register values below 0.1 mg/l while M1 and M4 are 0.1 and 0.4 mg/l, the four points present results that are well below the quality criteria complying with the regulations (table 5).

Finally, in regard to sulfates, the concentrations do not vary considerably among the points sampled, with M4 having the highest concentration of 12 mg/l, even so, these values are below the quality criteria established by the regulations Table 6).

The values obtained for fecal coliforms vary at each point, remaining below the quality criteria and complying with regulations. We observe that at points M1 and M4 there is an increase in values of 161 and 200 NPM/100ml, respectively, due to the fact that these are more populated sectors, causing an increase in the organic load (Table 7).

Hydrogen potential pH.

For the pH variable, we worked with an estimated 12 data, where the values are in a range of 7.15 to 7.59 U of pH. As shown in Table 4 below.

Table 4
Analysis results for pH - U of pH.

	M1	M2	M3	M4
1	7,58	7,49	7,53	7,16
2	7,59	7,49	7,54	7,15
3	7,59	7,48	7,54	7,16
Prom	7,59	7,49	7,54	7,16

Note: This table shows the average of the results for hydrogen potential pH obtained from the physicochemical analysis, taking the average for 3 samples at each of the four sampling points (own elaboration).

Nitrites
For the nitrite variable, we worked with an estimated 12 data, where the values are in the range of 0.07 to 0.14 mg/l, as shown in Table 5.

Table 5
Analysis results for biochemical nitrite demand mg/l.

	M1	M2	M3	M4
1	0,10	0,07	0,08	0,14
2	0,10	0,06	0,08	0,13
3	0,09	0,07	0,07	0,14
Prom	0,10	0,07	0,08	0,14

Note: This table shows the average of the results for nitrites obtained from the physicochemical analysis, taking the average for 3 samples at each of the four sampling points (own elaboration).

Sulfates
For the sulfate variable, we worked with an estimated 12 data, where the values are in the range of 9.00 to 12.00 mg/l (Table 6).

Table 6
Analysis results for sulfates mg/l.

	M1	M2	M3	M4
1	9,01	9,00	9,00	12,01
2	8,99	9,00	8,99	12,00
3	9,01	8,99	9,01	12,00
Prom	9,00	9,00	9,00	12,00

Note: This table shows the average of the results for sulfates obtained from the physicochemical analysis, taking the average for 3 samples at each of the four sampling points (own elaboration).

The relationship between population and these parameters is directly proportional, i.e., in those areas with a higher population density and an inadequate sanitation system, the results are slightly affected, presenting a higher organic load in the receiving waters and, therefore, with slightly higher values of BOD5 and fecal coliforms at points M1 and M4 compared to points M2 and M3.

Results for fecal coliforms.

For the fecal coliform variable, we worked with an estimated 12 data, where the values range from 41 to 200 NMP/100 ml (Table 7).

Table 7.
Analysis results for fecal coliforms NMP/100 ml.

	M1	M2	M3	M4
1	161,00	110,00	41,00	200,00
2	161,00	110,00	41,00	200,00
3	161,00	110,00	41,00	200,00
Prom	161,00	110,00	41,00	200,00

Note: This table shows the average of the results for fecal coliforms obtained from the physicochemical analysis, taking the average for 3 samples at each of the four sampling points (own elaboration).

Water quality index ICA.
In addition, the quality index was determined using the ICA-NSF methodology used in the United States.

$$ICA - NSF = \sum_{i=l}^{i=n} Q_i * W_i$$

The data obtained from the calculation of the ICA-NSF quality index for the samples of the four different points selected for the study were 57.64 for the sample of the first point, 59.64 for the sample of the second point, 62.76 for the sample of the third point and 56.02 for the sample of the fourth point; these values indicate that the quality index of the four points is in the medium category, It should be noted that the value of phosphate content was not included for each sample analyzed, which would represent a weighting that would increase the AQI value, thus obtaining a more significant and representative index of the degree of contamination and the water quality rating could have a more acceptable value on this rating scale.

The ICA water quality index was obtained considering the values obtained in the physicochemical analysis at each sampling point, which is shown in Tables 8, 9, 10, 11.

Table 8.

ICA shows at point 1: Water from the river near the Amelia farm, before joining the crystal river.

Parameter	Result	Units	Q-value	Wi	Subtotal
pH	7,59	U of pH	94	0,11	10,34
Temperature	30,00	°C	9	0,10	0,9

OD	72,50	%	73	0,17	12,41
TDS	88,00	mg/l	85	0,07	5,95
Turbidity	9,22	NTU	78	0,08	6,24
BOD	5,85	mg O2/l	50	0,11	5,50
CF	161	MPN/1000 ml	40	0,16	6,40
Nitrates	0,16	mg/l	99	0,10	9,90
		Water quality index Pt. 1:			57,64

Note: This table shows the results obtained from the physicochemical analysis, the corresponding Q value from the graphs established by Brown (1970) - NSF quality function, and the water quality index AQI after applying the formula, for sampling point 1: river water near the "Amelia" farm before joining the crystal river.

Table 9

ICA sample taken at point 2: Santa Rosa River - near the "El Beldaco" farm.

Parameter	Result	Units	Q-value	Wi	Subtotal
pH	7,49	U of pH	93	0,11	10,23
Temperature	29,40	°C	9,5	0,10	0,95
OD	69,90	%	70	0,17	11,90
TDS	76,00	mg/l	85	0,07	5,95
Turbidity	18,80	NTU	69	0,08	5,52
BOD	2,76	mg O2/l	75	0,11	8,25
CF	110	MPN/1000 ml	44	0,16	7,04
Nitrates	0,23	mg/l	98	0,10	9,80
Phosphates	---	---	---	0,10	---
		Water quality index Pt. 2:			59,64

Note: This table shows the results obtained from the physicochemical analysis, the corresponding Q value from the graphs established by Brown (1970) - NSF quality function, and the ICA water quality index after applying the formula, for sampling point 2: Santa Rosa River - near the "El Beldaco" farm.

Table 10

ICA sample taken at point 3: San Pablo River near the Universidad Técnica de Babahoyo.

Parameter	Result	Units	Q-value	Wi	Subtotal
pH	7,54	U of pH	94	0,11	10,34
Temperature	28,40	°C	10	0,10	1,00
OD	72,90	%	74	0,17	12,58

TDS	84,00	mg/l	86	0,07	6,02
Turbidity	13,60	NTU	72	0,08	5,76
BOD	2,67	mg O2/l	74	0,11	8,14
CF	41	MPN/1000 ml	57	0,16	9,12
Nitrates	0,21	mg/l	98	0,10	9,80
Water quality index Pt. 3:					62,76

Note: This table shows the results obtained from the physicochemical analysis, the corresponding Q value from the graphs established by Brown (1970) - NSF quality function, and the ICA water quality index after applying the formula, for sampling point 3: San Pablo River at the height of the Technical University of Babahoyo.

Table 11

ICA sample taken at point 4: San Pablo River - sector 4 de mayo

Parameter	Result	Units	Q-value	Wi	Subtotal
pH	7,16	U of pH	91	0,11	10,01
Temperature	28,80	°C	10	0,10	1,00
OD	67,10	%	66	0,17	11,22
TDS	104,00	mg/l	85	0,07	5,95
Turbidity	26,10	NTU	56	0,08	4,48
BOD	3,54	mg O2/l	68	0,11	7,48
CF	200	MPN/1000 ml	38	0,16	6,08
Nitrates	0,22	mg/l	98	0,10	9,80
Water quality index Pt. 4:					56,02

Note: This table shows the results obtained from the physicochemical analysis, the corresponding Q value from the graphs established by Brown (1970) - NSF quality function, and the water quality index AQI after applying the formula, for sampling point 4: San Pablo River - sector 4 de mayo.

When calculating the AQI - NSF of the average of the results of the parameters of the four monitoring points, a value of 59.73 was obtained for the General Water Quality Index, this value, reviewing Table 2, indicates that this water source is of "Medium" quality, taking into consideration that the value of phosphate content was not included for each sample analyzed, which would represent a weighting that would increase the value of the AQI and therefore it is estimated that the water quality rating could have a more acceptable value on this rating scale. As shown in Table 12 and 13, the AQI was obtained from the average of the values obtained in the physicochemical and NSF analysis.

Table 12

ICA for the average values of all samples.

Parameter	Average Results	Units	Q-value	Wi	Subtotal
pH	7,45	U of pH	92	0,11	9,13
Temperature	29,15	°C	11	0,10	1,10
OD	70,60	%	74	0,17	12,58
TDS	88,00	mg/l	85	0,07	5,95
Turbidity	16,93	NTU	68	0,08	5,44
BOD	3,71	mg O2/l	70	0,11	7,70
CF	128	MPN/1000 ml	44	0,16	7,04
Nitrates	0,21	mg/l	98	0,10	9,80
	Overall water quality index of the average:				59,73

Note: This table summarizes the results obtained from the physicochemical analysis, the corresponding Q value from the graphs established by Brown (1970) - NSF quality function, and the ICA water quality index after applying the formula; it represents the average values of all the samples taken for the investigation.

Table 13.

NSF water quality index results at each monitoring point.

Sampling points	Location	ICA - NSF	Ranking
Item 1	Water from the river near the Amelia farm, before joining the crystal river.	57,64	Media
Item 2	Santa Rosa River - near the "El Beldaco" farm	59,64	Media
Item 3	San Pablo River near the Universidad Técnica de Babahoyo	62,76	Media
Item 4	San Pablo River - 4 de mayo sector	56,02	Media

Note: This table summarizes the results obtained after applying the formula for calculating the NSF water quality indexes at each monitoring point.

4. Discussion

The main objective of this research work is to evaluate the quality for irrigation of agricultural crops of the surface waters of the San Pablo river basin, located in the city of Babahoyo, this was done through the physical, chemical and microbiological analysis of water samples from the natural source studied; the results obtained provided us with important information regarding water quality compared with environmental regulations Book Vi, Annex 1, Table 3. Admissible quality criteria for water intended for agricultural use, it was possible to conclude that the variables of pH, nitrites, sulfates and fecal coliforms are within the ranges or values established by the regulations, so it is concluded that the water at point 1: Water from the river near the Amelia farm, before joining the crystal river, point 2: Santa Rosa River - near the "El Beldaco" farm, point 3: San Pablo River near the Technical University of Babahoyo, and point 4: San Pablo River - 4 de mayo sector, comply with Ecuadorian environmental regulations.

Considering that the concentrations of CF in the water taken at point 1 (waters near the Amelia farm) and at point 4 (San Pablo river in the sector of the 4 de mayo citadel), are values that increase significantly in relation to point 2 (Santa Rosa river, near the "El Beldaco" farm) and point 3 (San Pablo river near the Technical University of Babahoyo), this increase in the results is related to the fact that these points are very close to the influence of the inhabitants of the city of Babahoyo, at point 4 and at point 1 near the "El Beldaco" farm, This increase in the results is related to the fact that these points are very close to the influence of residents of the city of Babahoyo. At point 4 and point 1, near the El Beldaco farm, there is a certain amount of settlement of people, which is attributed to the possible discharge of domestic wastewater into the river without any prior treatment; even so, the values obtained are within the maximum permissible limit, making it possible to use them for irrigation purposes in the area's crops.

The pH is in values between 7.16 and 7.59 U of pH, this is a good indication of water quality, since together with the temperature and dissolved oxygen, it influences the stability of biological processes, therefore this favors the development of microorganisms involved in the process of degradation of organic matter, as well as in the process of photosynthesis of plants and algae which contribute to the amount of oxygen available.

4.3 Nitrite values at all points are very low, ranging between 0.07 mg/l and 0.14 mg/l, this is due to the fact that it is very unstable in the environment as it goes through the nitrification and denitrification process. The four sampling points comply with environmental regulations for the nitrite parameter. Sulfates can be considered, together with chlorides, as components of high pollutant risk since they contribute to water salinity (Campos, 2022). The analyzed samples contain quantities lower than the maximum permissible limits established by Ecuadorian environmental regulations, 250 mg/l, so that by presenting values between 9.00 mg/l and 12 mg/l of sulfates, the established quality standards are met.

The values of biochemical oxygen demand are between 2.67% at point 3 (San Pablo river at the height of the Technical University of Babahoyo) as a minimum value and with a maximum value of 5.85% at point 4 (San Pablo river, sector 4 de mayo), this corresponds to the amount of dissolved oxygen in the water, which is necessary for the aerobic oxidation of organic substances present in the water, therefore, it is an indicator of the general quality of water and organic pollution (Cajaleón, 2020). Organic contamination would cause in plants an accumulation of the same in the roots or extremities of vegetables, and this will have repercussions on consumers.

Dissolved oxygen is found in a range of values between 67.10% and 72.90%, which we can consider as an indicator of water quality since, if there are very low or zero levels of dissolved oxygen, this would indicate a possible high contamination, septic conditions of contaminating organic matter or intense bacterial activity (consumption of dissolved oxygen) and this would affect the respiration processes, photosynthesis processes and the preservation of aquatic life (Bustos, 2019). Temperature is a factor that conditions the behavior of the internal components of water, according to (Cajas et al, 2023). Temperature affects the solubility of gases, which is important, since an increase in temperature decreases the solubility of oxygen in the water, and also affects the sedimentation rate of solids. In the results obtained, the temperature presents considerable values between 28.80 and 30.0 °C.

The values obtained for temperature, dissolved oxygen, total dissolved solids, nitrates, biochemical oxygen demand, and turbidity could not be validated with the environmental regulation Book VI, Annex 1, Table 3. Admissible quality criteria for water intended for agricultural use, since it does not consider them as critical variables to be considered in accordance with their use.

5. Conclusions

When analyzing the results of the investigation, it can be seen that at point 4, the results show a difference in the values corresponding to total dissolved solids, turbidity and fecal coliforms, this is because this sample was taken in the San Pablo river, sector 4 de mayo, This is due to the fact that this sample was taken in the San Pablo river in the 4 de Mayo sector, which is part of the urban area of the city, an area influenced by residents who use the water source for their daily cleaning activities, in addition to the fact that several lubrication plants and a gasoline distributor are located very close to the sampling point. These have their water treatments prior to sending their effluent to the receiving water body, which contributes to the fact that although the values are higher than those of the other three points, they comply with environmental regulations regarding fecal coliforms, pH, nitrites and sulfates.

In each of the sampling points, the water quality index ICA-NSF was determined, with which it can be established that in the four points the water quality is in the "regular" category, in general the parameters used for this quality criterion do not have a great influence on the result, the result obtained is influenced by the absence of the phosphate value, for this reason it is inferred that if we had these values, the water quality index could be in the "good" category.

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